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A COST/BENEFIT MATRIX MODEL OF NUCLEAR DETERRENCE

Mark Barbero

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THESIS

A COST/BENEFIT MATRIX MODEL
OF
NUCLEAR DETERRENCE

by

Mark Barbero

March 1975

Thesis Advisor: D. L. Abbey

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This thesis develops a cost/benefit matrix model of deterrence processes. The model is designed to assist analysis of complex multi-nation interactions when an issue vital to the national survival of each participant is in the balance.

A variety of interactions are examined utilizing the model to determine if deterrence exists. The analysis of the various

interactions results in the conclusion that deterrence exists when an assured destruction capability exists. Further, deterrence is lost in certain cases when the assured destruction capability is not maintained.

A Cost/Benefit Matrix Model
of
Nuclear Deterrence

by

Mark Barbero
Lieutenant, United States Navy
B.S., United States Naval Academy, 1969

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

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A variety of interactions are examined utilizing the model to determine if deterrence exists. The analysis of the various interactions results in the conclusion that deterrence exists when an assured destruction capability exists. Further, deterrence is lost in certain cases when the assured destruction capability is not maintained.

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I. THE NUCLEAR POLICY PROBLEM

Deterrence has been recognized as an integral component of strategy since man first fought his brothers for food. Military strategists throughout mankind's history have endorsed the concept of deterrent force, both in theory and in the field.

Man is no longer limited to the power of the club when disputing his neighbor. Today man holds the power and technological expertise to reach out from the planet of his birth, light his cities and feed his hungry. It is with this same power and technology that nations can eradicate cities, devastate populations, and contaminate the Earth.

Deterrence was modified in scope as the power and number of nuclear nations increased. The production and testing of the first nuclear devices changed not only the face of warfare but also the international view of war. The purpose of this thesis is to investigate deterrence theory and propose a deterrence process model based on mutual multi-nation deterrence.

A. NUCLEAR WEAPON POWER

To comprehend the magnitude of destruction concomitant with the failure to develop a viable nuclear policy, it is first necessary to understand the power of nuclear weaponry. Brown, in his book NUCLEAR WAR, demonstrates the increase in destructive power that nuclear weaponry provides. Brown states that,

"The highlight of Napoleon's 1812 campaign against Russia was the battle of Borodino, and in the course of it his armies expended the equivalent of about forty tons of TNT. The last classic fleet action of history was the battle of Leyte Gulf which the Americans won by expending 700 tons of TNT. The British fired off some 50,000 tons in their Somme Offensive of 1961, but it took them three weeks to do it. But another total war might involve the release of explosive energy equivalent to 100,000,000,000 tons of TNT."[1]

The devastating effects of nuclear power were first experienced by the inhabitants of Hiroshima, Japan on the sixth of August 1945. Due to the delivery and detonation of a single nuclear device, 64,000 Japanese perished.[2] Three days later, a second device with the equivalent explosive power of 20,000 tons of TNT was delivered and detonated over the Japanese city of Nagasaki causing 39,000 deaths.[3]

Professor Henry D. Smyth, a consultant to the MANHATTEN PROJECT, said that the first atomic devices were,

"A weapon... that is potentially destructive beyond the wildest nightmare of the imagination."[4]

In 1973, the document, THE MILITARY BALANCE 1972-1973, stated that the Soviet Union was reported to have a nuclear warhead which upon detonation would generate the equivalent explosive power of twenty-five million tons of TNT. Such a weapon would be more than one thousand times as powerful as the weapons which obliterated Hiroshima and Nagasaki. The potential

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[1] Brown, N., Nuclear War, p. 14, Praeger, 1964.

[2] Oughterson, A. W. and Shields, W., Medical Effects of the Atomic Bomb in Japan, p. 2., McGraw-Hill, 1956.

[3] ibid, p. 2.

[4] Gisvannitti, L., The Decision to Drop the Bomb, p. 307, Coward-McCann, 1965.

destructive power envisioned by Professor Smyth has increased through weapon development to the extent that a total nuclear war might result in the destruction of civilization.

B. NUCLEAR WEAPON NUMBERS

The magnitude of destruction resulting from a nuclear conflict is dependent on both the power and number of weapons detonated. The increase in nuclear weapon numbers has been dramatic.

The first production run of nuclear weapons, in the last months of World War II, was limited to approximately twelve devices.[5] In 1948 the nuclear stockpile of the United States probably did not exceed one hundred and fifty weapons.[6] The United States exercised its monopoly of nuclear weapon production with restraint.

The announcement by Molotov in late 1947 that, "There is no longer any secret about the atomic bomb," and the confirmation on 23 September 1949 that the Soviet Union had detonated an atomic device broke the United States' nuclear weapon production monopoly.[7] The Soviet development of nuclear weapons production facilities, and the weapons that those facilities produced, spurred the United States to increase its nuclear inventory. The nuclear weapons arms race had begun in earnest.

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[5] Atlantic Monthly, "The Balance of Military Power," p. 23, June 1951, vol. 187, no. 6.

[6] Questor, G.H., Nuclear Diplomacy, pp. 18-23, Dunellen, 1970.

[7] New York Times, November 7, 1947.

Exact nuclear warhead figures are not available due to national security considerations. Though exact figures are not available, they can be estimated from analysis of production facility capabilities and fissile material production. A 1964 study utilizing such an analysis determined that Great Britain had perhaps 1,500 nuclear warheads and France had several hundred.[8] In 1970 the same procedure applied to China resulted in an estimated Chinese nuclear stockpile of several dozen warheads.[9] United States' nuclear forces projected to 1977, from the base year of 1972, would credit it with 9,690 warheads.[10] The same projections for the Soviet Union would estimate the Soviet inventory at 6,750 warheads.[11] Combining the above projections and estimates yields a world stockpile approaching 20,000 nuclear warheads by 1977. The tremendous increase in nuclear warhead numbers compounds the problem of developing and maintaining a viable nuclear policy.

C. NUCLEAR PROLIFERATION

The complex problem of nuclear policy development is complicated not only by the magnitude and number of weapons in existence, but also by the number of nations which possess such devices. As the number of nations possessing nuclear weaponry

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[8] SIPRI Yearbook of World Armaments and Disarmaments 1969/1970, p. 381, Stockholm International Peace Research Institute, 1970.

[9] ibid. p. 381.

[10] Quanbeck, H.A., and Blechman, B.M., Issues for the Mid-Seventies, p. 26, Brookings Institute, 1973.

[11] ibid. p. 381.

increases, the number of divergent national interests served also increases. In 1945 the United States was the only nation that had the ability to utilize nuclear weapons in pursuit of its national interest. Six nations had the ability to utilize nuclear weapons in pursuit of their various national interests by 1974.

The increase in the number of nuclear nations and the speed with which the increase has taken place poses an additional dimension of complexity to the problem of nuclear policy development. Table I shows the date each of the nuclear nations entered the nuclear arena. The average rate of entry to the nuclear club has been approximately one nation every six years.

DATES OF FIRST NUCLEAR TEST[12]

Nation	First Nuclear Test	Time Lag From Previous Entry
United States	16 July 1945	Not Applicable
Soviet Union	23 September 1949	4 Years
United Kingdom	2 October 1952	3 Years
France	13 October 1960	8 Years
China	16 October 1964	4 Years
India	18 May 1974	10 Years

TABLE I

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[12] SIPRI, op. cit. p. 381.

D. FUTURE NUCLEAR NATIONS

The nuclear policy-making problem is further confused by nations possessing the capability of nuclear weapon development, for they appear to be the most likely to enter the nuclear arena in the future. In 1966, nine nations were credited with the economic, technological and industrial capability necessary for the development of nuclear weaponry. The nine nations were the Federal Republic of Germany, Canada, Sweden, Switzerland, Israel, Italy, India, Japan, and Australia.[13] Other nations have since developed the required capabilities, and India has entered the nuclear arena by detonating its first device in 1974. It must be assumed that additional nations will utilize their nuclear development capabilities and "go nuclear" within the next few decades.

Though emerging nuclear nations may require several years or even decades before they individually or in concert can challenge the lead in nuclear weaponry of the two pre-eminent super-powers, their mere existence requires re-evaluation of existing nuclear policies. As emerging nations increase their stockpiles, their impact on the nuclear policies of the other nations also increases.

To summarize, the problem of viable nuclear policy formulation is complicated by the dramatic increase in weapon numbers and individual weapon power. These increases coupled with the

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[13] Knorr, K.E., On the Uses of Military Power in the Nuclear Age, p. 119, Princeton University Press, 1966.

rapidly expanding number of nuclear nations dictates a continuous re-examination and modification of existing nuclear doctrines. Nuclear policy formulation must be dynamic if it is to cope with continued increases in nuclear nations and nuclear weapon numbers. A static nuclear policy, in light of the rapidly changing nuclear situation, is insufficient to promote the stability of nuclear deterrence and could promote the disastrous consequences that a failure of nuclear deterrence entails.

II. NUCLEAR DETERRENCE AND THE DETERRENCE PROCESS

A. CAPABILITY

In order to elucidate some of the basic tenets of various nuclear deterrence policies it is first necessary to define two primary concepts. The two concepts are capability and credibility.

Nuclear capability consists of two prerequisites. First, a nation must have a nuclear device, and, second, it must possess a delivery system or vehicle. Neither the device nor the delivery vehicle is sufficient by itself to constitute a nuclear capability.

There exist various levels of capability. The level of capability any nation possesses at any particular time is dependent upon weapon numbers, weapon power, reliability of delivery systems, targeting doctrine and other less significant factors. There is no particular number of weapons which equates to a specific level of capability in all situations. However, there are some useful concepts which stem directly from capability when viewed in a situational context.

A first strike nuclear capability is one of the various levels of capability which is dependent upon the situational context. A first strike nuclear capability is that level of nuclear weapons and delivery systems which allows one nation to launch a devastating nuclear attack against another nation. For the purposes of this thesis, such a strike against another

nation, which also possesses a nuclear first strike capability, is assumed to destroy sufficient numbers of the opponents weapons to negate any attempt to respond to the first strike in kind.

A second strike nuclear capability is that level of nuclear weapons and delivery systems which allows a nation possessing such a capability to absorb another nation's first strike and have sufficient remaining weapons to devastate the attacker. Such a capability has also been defined as an assured destruction capability, in that the launch of a first strike against such a nation invites that nation's second or retaliatory strike. A nation with an assured destruction capability ensures that its enemy will be destroyed, even if it attacks without warning, by maintaining sufficient numbers of weapons and delivery systems.

Such terms as first strike, second strike, and assured destruction capability are valid only in a situational context. The level of capability which would provide China with assured destruction of India in the event of nuclear war is not necessarily the level which will give it the same capability against the Soviet Union. Similarly, though India may possess a first strike capability against Pakistan, that level would not necessarily be sufficient to provide it with a first strike capability against the United States.

B. CREDIBILITY

Credibility may be defined as believability. The concept of credibility is equally applicable to an analysis of one's

own nuclear capabilities as it is to an opponent's. What a nation believes of its own capabilities, how it perceives its opponents view of its nuclear capabilities, and how it views its opponent's capabilities are all part of the complex concept of credibility.

The number of weapons possessed or believed to be possessed by an opponent affects the credibility of the opponent's nuclear effectiveness. Due to secrecy of nuclear matters, exact information concerning enemy weapon strength and targeting doctrine is incomplete at best. Projected probabilities, weapon characteristics, targeting doctrine, defense capabilities, and a host of other factors may reinforce or detract from the belief that one's own nation or an opponent possesses a specific level of capability. Such a belief may have no basis in the reality of the situation, and may in fact be a complete perceptual error.

C. DETERRENCE AND THE DETERRENCE PROCESS

Capability and credibility are inter-related and integral parts in the concept of nuclear deterrence. The term 'deterrence' has a profusion of definitions, and has been defined at various times as follows:

> "(Deterrence)---prevents an enemy power taking the decision to use armed force; (by causing him), to act or react in the light of the existence of a set of dispositions which constitute an effective threat."[14]

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[14] Beaufre, A., Deterrence and Strategy, p. 24, Praeger, 1965.

"(Deterrence) is the power of reprisal and the knowledge that the means of reprisal exists."[15]

"(Deterrence) is the ability to influence someone not to do something."[16]

"(Deterrence) is a species of political power having the capacity to induce others to do things or not do things which they would not otherwise do or refrain from doing."[17]

For the purposes of this thesis, and in the interest of clarity, it is necessary to more stringently define deterrence. Deterrence in this analysis is limited strictly to the concept of nuclear deterrence, and is defined as an actual or implied threat of nuclear force by one or more nations which results in a decision by an opponent to forego initiating the use of his nuclear weapons.*

From the basic definition of deterrence, it is possible to construct the minimum criteria if deterrence (nuclear) is to exist. Deterrence, in order to exist, requires an interaction by two or more nations each of which has some level of credible nuclear capability. In a situation where a nation has no rivals with which to contend the deterrence concept is not operative. It is not sufficient to stipulate that the two or more nations involved are interacting. They must

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[15] Quester, G.S., Deterrence Before Hiroshima, Wiley, 1966.

[16] Teti, F.M., A Study of Deterrence, p. 107, Naval Postgraduate School, 1972.

[17] Snyder, G.H., "Deterrence and Power," p. 163, Journal of Conflict Resolution, June 1960, vol. 4, no. 2.

*Deterrence and nuclear deterrence may be considered for the purposes of this thesis as synonyms.

be in conflict. Nations which pursue courses of action which are not in conflict with other nations do so unencumbered by problems which stem from opposition and consequently avoid being deterred.

The capability each nation possesses may or may not exist in reality. It is necessary only that a nation perceive as credible an opponent's nuclear capability. For deterrence to exist, it is necessary that each nation pose a credible nuclear threat to the others.

Nuclear capability and credibility are not the sole prerequisites for deterrence. The knowledge that an opponent possesses a nuclear force is not sufficient to deter an aggressor unless it is perceived that the opponent also possesses the resolve to utilize its force in opposition to the contemplated action. The national resolve to utilize nuclear force is directly related to the perceived value of the issue in conflict. Recent international interaction do not contradict the hypothesis that nuclear force and the threat of its use ? are instituted only when the nations involved perceive the issue in conflict to be vital to national security and survival.*

To summarize, for deterrence to exist there must be at least two nations each with some credible nuclear capability in conflict. Further, each nation must perceive that its opponent has the resolve to utilize nuclear forces as threatened.

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*The Cuban Missile Crisis is a prime example.

When these conditions exist, and nuclear exchange is not generated, deterrence can be said to exist.

III. NUCLEAR DETERRENCE POLICY

United States nuclear deterrence strategy as a national policy had its start with the detonation of two nuclear devices during World War II. The detonation of those two weapons established that the United States had a nuclear capability. Nuclear weapons were a reality. More importantly, the United States had demonstrated its resolve to utilize its nuclear monopoly to support and assist in the pursuit of its national aims. Through the detonation of those two nuclear devices the United States had established the two basic tenets of nuclear deterrence, capability and credibility.

A. DETERRENCE DOCTRINE

Further amplification of nuclear policy was neither forthcoming nor necessary due to the nuclear monopoly possessed by the United States. In fact a complete doctrine of deterrence through threat of nuclear retaliation was not developed until well after 1947.[18] It has been often speculated that the elucidation of nuclear deterrence policy was prodded by the Soviet Union's detonation of its first nuclear device in 1949.

Lack of a complete deterrence doctrine is attested to by the fact of limited nuclear weapons production prior to Soviet entrance to the nuclear arena. The United States' near

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[18] Questor, G.H., Nuclear Diplomacy, pp. 4-6, Dunellen, 1970.

curtailment of planned nuclear testing during the Berlin crisis of 1948 strongly implies the existence of only a minimal nuclear stockpile and an incomplete targeting doctrine.[19] Without adequate weapon numbers and a complete targeting doctrine, claims of a formal nuclear deterrence policy lack credence.

With the detonation of its first nuclear device the Soviet Union broke the nuclear weapon monopoly held by the United States. The United States could no longer threaten the use of its nuclear weapons with impunity. The implicit general policy of containing the Soviet Union's aggressive tendencies with the threat of nuclear force became increasingly less credible as the Soviet stockpile increased. The general policy of containment, in order to be viable in a world characterized by two nuclear nations, required a more explicit statement as to national objectives and strategies.

B. NSC-68

The required re-evaluation came in the form of NSC-68. This document has been called, "the first comprehensive statement of a (United States) national strategy."[20] It presented in detail various national strategies available to the United States. The option chosen by the United States was one of collective security and containment of the Soviet Union and

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[19] ibid. pp. 4-6.

[20] Teti, op. cit. p. 39.

the People's Republic of China. The narrowness of the general policy of containment had been replaced with a more complete doctrine of collective security and containment.

C. NSC-162

As Unites States nuclear forces expanded and general purpose forces declined, NSC-68 became untenable. NSC-162 replaced NSC-68 and expounded the virtues of massive nuclear retaliation during the envisioned longterm idealogical conflict with the Soviet Union.[21]

The strategy of massive retaliation incorporated a substrategy, often referred to as the "trip-wire." This substrategy entailed initiating a nuclear attack against the Soviet Union if the Soviet Union were to trip the wire of American response by attacking NATO forces in Europe. Such a strategy attempted to make credible the idea that nuclear force could and would be utilized to ensure victory for the NATO forces.

Continued Soviet development of nuclear weapons and delivery systems coupled with the maintenance of large conventional forces decreased the credibility of massive retaliation. In the words of one European commentator, referring to the policy of massive retaliation,

> "Our (NATO's) present policy, which Mr. Dulles has labeled 'massive retaliation' seems to be becoming too drastic and inflexible for these objectives. Increasingly, we are getting into a position where, in effect, we shall be forced to

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[21] ibid. p. 114.

threaten, and if necessary initiate, the destruction of civilization in the event of any measure of aggression too powerful for our small conventional forces to combat."[22]

D. FLEXIBLE RESPONSE

In 1962 a new policy embracing flexible response was instituted. Flexible response was articulated as allowing the armed forces of the United States to be employed as required, to the degree required, when required, in the manner required. The policy of flexible response no longer restricted the United States to an all-or-nothing conflict. This new doctrine was supported by an increase in expenditures for general purpose conventional forces, thereby allowing a truly flexible response in the conventional as well as the nuclear arena.

The doctrine of flexible response was developed primarily to avert total war and to allow for the resolution of conflict at significantly lower levels of combat and destruction. In the general policy of flexible response various targeting strategies have been embraced. The two most widely accepted targeting doctrines are counterforce and countervalue.

Counterforce targeting is based upon the concept that the threat of delivery of nuclear weapons against the opposition's military forces is sufficient to avoid maximum nuclear retaliation by limiting nuclear destruction and removing the threat to national survival. Countervalue targeting is more encompassing in that it is based upon the belief that targeting

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[22] Buzzard, A., "The H Bomb, Massive Retaliation or Graduated Deterrence," p. 148, International Affairs, April 1956, vol. 32, no. 2.

should include population and industrial centers as well as military installations. Where counterforce targeting envisions a limited nuclear exchange with minimal damage to population and industrial centers, countervalue targeting envisions a weapons exchange on a city-for-city, installation-for-installation basis.

Both counterforce and countervalue targeting are viable targeting doctrines at levels of conflict below that level of nuclear weapon exchange which would threaten national survival. As targeting doctrines, each offers additional levels of response which a nation may employ in order to avoid acting or reacting on a level which would endanger an opponent's or its own national survival. The ability to utilize additional levels of response may increase the amount of time a nation has in which to select alternative courses of action or re-evaluate its position, but ultimately nuclear deterrence must rest in the concept of assured destruction of the enemy.

Inasmuch as the concept of flexible response combines counterforce and countervalue targeting with an assured destruction capability, it is viable and indeed preferable. However, to ignore or underallocate sufficient resources to maintain an assured destruction capability is to destroy the ability to exercise a truly flexible response. It is vital that any nation which aspires to hold a position as a superpower and world leader be able to utilize a complete range of response and not one truncated at the ultimate level, that level being the assured destruction of one's enemies.

IV. THE CONCEPTUAL COST/BENEFIT MODEL

In order to develop a deterrence model, it is first necessary to accept three assumptions. First, it must be assumed that nations act in a rational manner in affairs directly linked to national survival. Second, it must be assumed that every nation possesses a unique national system of values with which it evaluates costs and benefits associated with various courses of action. The third assumption is that the loss of national survival is perceived as an infinite cost by each nation.

A. RATIONAL DECISION-MAKING

In analyzing the nuclear deterrence process, it is of primary importance to assume rational decision-making. Conceptual modeling techniques do not allow for irrational decision-making processes, though they definitely exist. Leadership characterized by lunacy does not lend itself to modeling. Rational and non-rational decision-making do lend themselves to process analysis.[23] When the decision-making apparatus of a nation is confronted with a situation where the decision is directly linked to national survival, this thesis assumes that a rational decision-making process will be utilized.

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[23] Allison, G.T., "Conceptual Models and the Cuban Missile Crisis," The American Political Science Review, vol. 63, no. 3, pp. 689-718.

B. NATIONAL VALUE SYSTEMS

Rational decision-making requires a comparison of alternatives against some criteria and toward some goal. The criteria utilized and the goal pursued are derived by a nation from its unique system of national values. Kennan alluded to the uniqueness of national value systems when he stated that nations should,

> "exercise the modesty to admit that ... (each nation's) national interest is all (it) is really capable of understanding."[24]

To accept Kennan is to accept that each nation does have a unique value system, and further, that its value system is the only one that it can accurately employ. Consequently, actions which appear rational to one nation's value system may seem non-rational or irrational when viewed through another system of values.

C. CONCEPTUAL COST/BENEFIT MODEL

It is from the set of national values that the conceptual modeling of cost/benefit relationships springs. Utilizing the assumption of rational decision-making and recognizing the importance of national value systems, Klaus Knorr developed a conceptual formula of cost/benefit relationships as applied to military power.[25] His model states that the utility derived from the development of a military force is equal to the

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[24] Kennan, G.F., American Diplomacy: 1900-1950, pp. 18-21, 143-144, Mentor, 1952.

[25] Knorr, op. cit. p. 9.

value placed upon the benefits derived from such a force minus the costs incurred. Knorr concludes that the utility is equal to the difference between aggregate benefits and aggregate costs. In mathematical symbology Knorr's concept can be expressed as follows:

$$V = \Sigma B - \Sigma C$$

The formula states that the value (V) of an action is equal to the summation of perceived benefits (ΣB) minus the summation of perceived costs (ΣC).[26]

D. MODEL APPLICATION

Knorr's model is especially useful in that it permits evaluation of alternative courses of action in situations involving potential nuclear conflict over issues threatening national survival of one or more nations. Applying Knorr's concept to a two nation interaction problem, the conceptual cost/benefit formulas for each nation may be developed subject to the following assumptions.

(1) Both nations involved in the interaction consider the issue to be vital to their national survival.

(2) Each nation possesses a nuclear first strike capability, and neither nation possesses a nuclear second strike capability.

(3) Neither nation can solve the problem by conventional means.

Utilizing the above assumptions for an interaction between two nations, Alpha and Bravo respectively, two alternative nuclear

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[26] ibid. p. 9.

courses of action appear feasible. The first is to launch a first strike, and the second is to refrain from launching a first strike. The cost/benefit formulas for Alpha are as follows:

(1) First Strike Launched

Value of First Strike = (Summation of Benefits from First Strike) - (Summation of Costs from First Strike)

$$V_{FS} = \Sigma B_{FS} - \Sigma C_{FS}$$

(2) No Strike

Value of No Strike = (Summation of Benefits from No Strike) - (Summation of Costs from No Strike)

$$V_{NS} = \Sigma B_{NS} - \Sigma C_{NS}$$

As previously stated, it is the national value system that allows for the valuation of the various alternative courses of action. It is, however, possible to evaluate the alternative courses of action presented here without comprehensive knowledge concerning the national value system if loss of national survival is considered to be an infinite cost. Applying the concept of infinite cost to the problem of alternative selection, two points become apparent. First, alternative (1) ensures the survival of the nation employing such an action by destroying its opponent and consequently resolving the issue in conflict in its favor. Second, alternative (2) is dependent upon the action the opposing nation implements. If the opposing nation opts for a "No Strike" policy, the issue in conflict will remain in conflict, with both nations' national survival

threatened. If the opposing nation opts for a "First Strike" policy, it will destroy its opponent and resolve the issue in conflict in its favor.

Examining the value of the two alternative courses of action in such a manner reveals that alternative (1) will have some value which may be positive or negative, but will in all cases be preferable to the value of alternative (2), given that the opposing nation implements its first strike option. Inasmuch as the alternative courses of action are applicable to both nation Alpha and Bravo, each nation will (due to the concept of infinite cost associated with loss of national survival) avoid those courses of action which allow that infinite cost to be exacted. In such a situation, both Alpha and Bravo would avoid alternative (2) and opt for alternative (1) as the only rational alternative to be pursued. In fact both nations may reasonably and rationally perceive the cost/benefit evaluation of alternative (1) as an imperative for launching a first strike, for it is the only course of action which ensures both national survival and resolution of the issue, regardless of an opponent's subsequent actions.

Though cost/benefit relationships become increasingly difficult to quantify and analyze as international implications are considered, the approach is useful if it is accepted that the loss of national survival is considered to be an infinite cost. Rational decision makers must consider the infinite cost associated with the loss of national survival and act accordingly. The model as presented may seem to imply

that two nations, each possessing a nuclear first strike capability, are doomed to engage in nuclear war. Such an implication is false, for only when those nations are involved in direct conflict over an issue, which is itself vital to the national survival of each, does the decision to launch a first strike become rational.

The cost/benefit model presented here is not a deterrence model. It is not a nuclear deterrence model because neither nation would rationally be deterred from the launch of its nuclear forces. The model demonstrates the applicability of the cost/benefit concept to interaction analysis between nuclear nations and is consistent with the assumptions of rationality, national value systems and infinite cost.

V. THE MULTI-NATION DETERRENCE MODEL

The concept of assured destruction through retaliatory response is not operative in a world characterized by only two nuclear nations each possessing only a first strike capability. In order to employ a truly flexible response, a nation must possess a broader range of nuclear capabilities.

The basis for analyzing flexible response multi-nation interactions is the cost/benefit analysis presented earlier. Expanding the basic cost/benefit interaction model for the two nation problem, it is possible to present the resultant values of alternative courses of action in a matrix format.

A. MATRIX PRESENTATION OF COST/BENEFIT FORMULATION

Subject to the same assumptions utilized in the two nation cost/benefit scenario depicted earlier, the value for the two alternative courses of action nations Alpha and Bravo may employ are as follows:

(1) First Strike Launched

Value of First Strike = (Summation of Benefits from First Strike) - (Summation of Costs from First Strike)

$$V_{FS} = \Sigma B_{FS} - \Sigma C_{FS}$$

(2) No Strike

Value of No Strike = (Summation of Benefits from No Strike) - (Summation of Costs from No Strike)

$$V_{NS} = \Sigma B_{NS} - \Sigma C_{NS}$$

As discussed earlier, alternative (1) is the only alternative which ensures survival of the nation employing it regardless of the action that the opposing nation implements. The value of alternative (1) can be equated to national survival, and presented in payoff matrix format as follows:

PAYOFF MATRIX FOR NATION ALPHA

Nation Bravo Alternatives

(1)--First Strike
(2)--No Strike

		B-1	B-2
NATION ALPHA ALTERNATIVES	A-1	Not Applicable	Survival
	A-2	Destroyed	Survival/Continued Conflict

Tracing nation Alpha's alternative A-1 across row 1 yields the same results that the cost/benefit model yielded, in that, a first strike by nation Alpha destroys nation Bravo and ensures Alpha's survival. Again referring to row 1, the payoff matrix addresses the incompatibility of both nations launching a first strike simultaneously. The matrix is also useful in demonstrating the value of alternative A-2. It displays that the value to Alpha of the alternative that it employs is dependent upon the alternative course of action that Bravo pursues. The results of the matrix can be seen to correspond to the results obtained from the cost/benefit equation analysis presented earlier. In addition, the matrix displays that if both nations

opt for a no strike strategy the result is survival with continued conflict. The continued conflict results from the fact that such a choice of alternatives will not resolve the original issue.

The payoff matrix for nation Bravo is identical to the one presented for Alpha due to the fact that each nation possesses the same options and capabilities. The equality of participant's matricies will not hold for all cases as will be demonstrated later.

B. TWO NATION UNEQUAL CAPABILITY MODEL

The utility of the matrix approach lies in its ability to deal with unequal levels of capability and multi-nation problems. The matrix approach allows for detailed analysis of possible alternatives and the determination as to whether or not deterrence is present in the interaction.

Utilizing the assumptions of rational decision-making, infinite cost associated with the loss of national survival, and a system of national values, the following scenario may be developed. Two nations, Alpha and Bravo, are involved in a conflict over an issue considered to be vital to the national survival of each. The issue can not be resolved by conventional means. Nation Alpha possesses an assured destruction capability against nation Bravo, and Bravo possesses a first strike capability against Alpha.

In the scenario, the following courses of action are considered possible.

ALPHA'S ALTERNATIVE COURSES OF ACTION

A-1 First Strike
A-2 No First Strike
A-3 Retaliatory Strike

BRAVO'S ALTERNATIVE COURSES OF ACTION

B-1 First Strike
B-2 No First Strike

Applying the concepts of cost/benefit relationships, and infinite cost associated with the loss of national survival, the value of each alternative course of action can be determined. The values can then be presented in a matrix payoff format. The payoff matrix for nation Alpha for the scenario as presented, is displayed in Table II.

PAYOFF MATRIX FOR NATION ALPHA

		Nation Bravo Alternatives	
		B-1	B-2
NATION ALPHA ALTERNATIVES	A-1	Not Applicable	Survival
	A-2	Destroyed	Survival/Continued Conflict
	A-3	Destroyed	Survival/Continued Conflict

TABLE II

As before, the matrix displays the assumption that simultaneous launch is not considered possible. In addition, it must be assumed that a course of action resulting in survival and resolution of the issue in conflict is preferable to one which results in survival with continued conflict. Examining

Table II, it is apparent that Alpha's rational choice of alternatives must be that of a first strike. Only a first strike strategy (A-1) ensures Alpha's survival and the resolution of the issue in conflict regardless of the course of action Bravo pursues.

A further simplification of Alpha's payoff matrix is possible. Inasmuch as strategies A-2 and A-3 present the same payoffs, they may be combined and presented as one strategy. Such a combination is conceptually valid when it is remembered that by definition a retaliatory strike can be employed by a nation only if it has not already utilized its first strike option.

ALPHA's ALTERNATIVE COURSES OF ACTION

A-1 First Strike
A-2 No First Strike, Retaliatory Strike If Attacked

The combined alternatives evaluated as before yields the simplified payoff matrix presented in Table III.

PAYOFF MATRIX FOR NATION ALPHA

		Nation Bravo Alternatives	
		B-1	B-2
NATION ALPHA ALTERNATIVES	A-1	Not Applicable	Survival
	A-2	Destroyed	Survival/Continued Conflict

TABLE III

The simplified payoff matrix displayed in Table III presents the same results as the expanded matrix. In both matricies, the preferability of strategy A-1 is apparent. Alternative A-1 is the only alternative which Alpha can pursue without risking loss of national survival. Acting rationally, Alpha would be faced with a decision where a first strike against Bravo would be imperative. From this analysis, it may be concluded that Alpha has not been deterred if it acts rationally.

A complete analysis of the scenario is not possible without an examination of Bravo's payoff matrix. Utilizing the complete set of alternatives presented earlier, Bravo's payoff matrix could be developed as in Table IV.

PAYOFF MATRIX FOR NATION BRAVO

		Nation Alpha Alternatives		
NATION BRAVO ALTERNATIVES		A-1	A-2	A-3
	B-1	Not Applicable	Survival	Destroyed
	B-2	Destroyed	Survival/ Continued Conflict	Survival/ Continued Conflict

TABLE IV

In analyzing Bravo's payoff matrix, there appears to be no dominate strategy. In fact a first strike strategy, (B-1), appears viable and of little more danger to national survival

than a no strike strategy, (B-2). The matrix, however, implicitly addresses the concept of credibility, in that, for Bravo to rationally employ a first strike strategy it must consider that the retaliatory strike Alpha possesses is not credible. If Bravo perceives that Alpha's strike is credible and would be employed, Bravo's payoff matrix would be altered. The certainty of response to attack could be represented by combining Alpha's alternatives as before. Combination of Alpha's alternatives would result in the simplified matrix presented in Table V.

PAYOFF MATRIX FOR NATION BRAVO

		Nation Alpha Alternatives	
		A-1	A-2
NATION BRAVO ALTERNATIVES	B-1	Not Applicable	Destroyed
	B-2	Destroyed	Survival/Continued Conflict

TABLE V

Table V demonstrates that due to the assumption that Alpha's retaliatory response is credible, Bravo is faced with a dominate strategy. By not employing a first strike strategy Bravo has a possibility for survival with continued conflict. A first strike strategy ensures Bravo's destruction and loss of national survival. As a rational nation, Bravo would be

forced to avoid any alternative which did not have some form of national survival as one of its outcomes.

The matrix analysis implies that Bravo would be rationally deterred from initiating a nuclear exchange only as long as it perceived that Alpha's retaliatory response was credible. Bravo's choice of a no strike alternative is directly dependent upon the credibility of Alpha's response. If Alpha's credibility is lost, Bravo may no longer be deterred.

Two important points may be drawn from this two nation interaction model. First, nation Alpha is not deterred, but instead has a first strike imperative. Second, nation Bravo is deterred by the assured destruction capability of its opponent only as long as the opponent's assured destruction capability remains credible.

C. TWO NATION EQUAL CAPABILITY MODEL

As the nations of the world increase their nuclear capability, additional levels of nuclear interaction are possible. Instead of only one of the participants being deterred, both may perceive a no strike strategy as the dominate strategy to be pursued. Such a situation arises when two nations in conflict each possesses an assured destruction capability against the other.

Utilizing the previous assumptions, the following courses of action may be considered feasible:

ALPHA'S ALTERNATIVE COURSES OF ACTION

A-1 First Strike
A-2 No First Strike, Retaliatory Strike If Attacked

BRAVO'S ALTERNATIVE COURSES OF ACTION

B-1 First Strike
B-2 No First Strike, Retaliatory Strike If Attacked

Applying the concept of cost/benefit relationships as before, the various alternatives may be evaluated. The results are presented in Tables VI and VII, for Alpha and Bravo respectively.

PAYOFF MATRIX FOR NATION ALPHA

		Nation Bravo Alternatives	
		B-1	B-2
NATION ALPHA ALTERNATIVES	A-1	Not Applicable	Destroyed
	A-2	Destroyed	Survival/Continued Conflict

TABLE VI

PAYOFF MATRIX FOR NATION BRAVO

		Nation Alpha Alternatives	
		A-1	A-2
NATION BRAVO ALTERNATIVES	B-1	Not Applicable	Destroyed
	B-2	Destroyed	Survival/Continued Conflict

TABLE VII

The payoff matricies for Alpha and Bravo are identical due to the identical capabilities and options that each nation possesses. Inasmuch as the payoffs are identical, the dominate strategy for Alpha must also be the dominate strategy for Bravo. The strategy of no first strike, being the only strategy which results in the possibility of survival, in any form, is the dominate strategy.

In such a situation, both nations would rationally be deterred from initiating a nuclear exchange, for to do so would ensure one's own destruction. It is the retaliatory capability of the opponent which makes the only rational decision that of opting for a no first strike strategy.

Until the capability or the credibility of the opponent's retaliatory response declines, mutual deterrence will exist. The nations involved will either compromise on the issue or alter their capabilities in order to ensure the resolution of the issue in their favor.

Comparing the two nation equal capability model to the two nation unequal capability model results in the following conclusions. First, if both nations possess assured destruction capabilities mutual deterrence will exist. Further, such deterrence will remain stable as long as each nation possesses its assured destruction capability and perceives that its opponent's retaliatory response is credible. Second, when one of the nations does not possess or fails to maintain an assured destruction capability, it presents its opponent with a first strike imperative. In any situation where there

exists a first strike imperative the nuclear balance of power is highly unstable.

D. THREE NATION EQUAL CAPABILITY MODEL

Assured destruction through retaliatory response is not the only cause of deterrence. Deterrence may also occur when none of the nations involved possesses more than a first strike capability if at least three such nations are interacting.

Utilizing the same assumptions applied to previous models, it is possible to develop a three nation interaction model. It is further assumed that each nation's first strike capability can be utilized only once, and if employed must be employed in its entirety against one opponent. Inasmuch as each nation possesses an identical capability, the same basic set of alternatives may be envisioned for each as follows:

ALPHA'S ALTERNATIVE COURSES OF ACTION

A-1 First Strike Against Bravo
A-2 First Strike Against Charlie
A-3 No First Strike

BRAVO'S ALTERNATIVE COURSES OF ACTION

B-1 First Strike Against Alpha
B-2 First Strike Against Charlie
B-3 No First Strike

CHARLIE'S ALTERNATIVE COURSES OF ACTION

C-1 First Strike Against Alpha
C-2 First Strike Against Bravo
C-3 No First Strike

In order to develop the resultant payoff matricies from the alternatives possible, the following additional assumptions are necessary:

1. No two nations act in concert.
2. Nations have no retaliatory capability if struck by another nation's first strike.
3. After launch of its first strike, no nation possesses any additional capability.

Due to the symmetry of alternatives and capabilities, a first strike by any one of the three opposing nations results in the same basic outcome. For example, it may be assumed that Alpha implements strategy A-1, a first strike against Bravo.

Implementation of strategy A-1 leaves Alpha with no remaining nuclear capability. Due to the effects of Alpha's strike, Bravo no longer possesses any nuclear capability and is for the purposes of this scenario destroyed as a nation. Charlie is the only nation which would possess a first strike capability and its full range of options. Analyzing the remaining alternatives the payoff matricies in Tables VIII and IX may be developed.

PAYOFF MATRIX FOR NATION ALPHA

Nation Charlie's Alternatives

NATION ALPHA ALTERNATIVES	C-1	C-2	C-3
A-1	Destroyed	Survival/ Continued Conflict	Survival/ Continued Conflict

TABLE VIII

PAYOFF MATRIX FOR NATION CHARLIE

	Nation Alpha Alternatives A-1
NATION CHARLIE ALTERNATIVES C-1	Survival
C-2	Survival/Continued Conflict
C-3	Survival/Continued Conflict

TABLE IX

Alpha's payoff matrix demonstrates that its survival is contingent upon Charlie either refraining from launching its first strike, or Charlie launching its first strike against Bravo. Charlie's payoff matrix demonstrates that the payoff derived from launching a first strike against Bravo is equal to the payoff derived from refraining to launch any strike. However, a strategy of first strike against Alpha ensures the survival of Charlie without continued conflict. Alternative C-1 is a dominate strategy for Charlie. Inasmuch as it is assumed that survival without continued conflict is preferable to survival with continued conflict, Charlie is presented with a first strike imperative against Alpha.

The scenario can be generalized due to equal capabilities and identical alternatives to yield the following conclusions. First, in a three nation interaction characterized by equal first strike capability, any nation which implements a first

strike presents the remaining nuclear nation with a first strike imperative. Second, nations would not rationally be willing to present a first strike imperative to an opponent by utilization of their first strike option. Consequently, the only rational option is the no strike option. Only by employing a no strike strategy can each nation ensure its survival. In essence, each nation is deterred from initiating a nuclear exchange by the remaining nation's nuclear capability and potential first strike option. The third nation's capability acts in the same manner as an assured destruction capability in a two nation model. In both scenarios deterrence exists, but it is the result of the number of participants in the three nation model presented here rather than a difference in capabilities.

E. THREE NATION MIXED CAPABILITY MODEL

The nuclear picture of the world today is that of two nations each with an assured destruction capability against the other, and a third nation rapidly developing a first strike capability. In addition to these three nations, three other nations possess some nuclear capability. As China develops its first strike capability nuclear policy decisions in both the Soviet Union and the United States will be affected. The evolving nuclear situation can be modeled as before.

Utilizing the same basic set of assumptions of rationality, infinite cost associated with loss of national survival, and a system of national values, the following scenario may be developed. Three nations are in conflict over an issue each

perceives as vital to its national survival. Two of the nations, Alpha and Bravo, each possess an assured destruction capability against each other. The third nation, Charlie, possesses only a first strike capability. Subject to the following additional assumptions the payoff matrix for each of the nations can be developed.

1. The assured destruction capability of Alpha and Bravo permit them to absorb a first strike from any one nation and respond with sufficient weapons to devastate their attacker.

2. Neither Alpha or Bravo have sufficient weapons to launch the equivalent of two first strikes, or to launch a first strike and a devastating retaliatory strike.

3. Nation Charlie has the capability to launch only a first strike and if struck with a first strike will not be capable of response.

4. No two nations act in concert.

5. Assured destruction nations employ their retaliatory response against the nation which attacks them.

Subject to the above assumptions, the following alternative courses of action appear feasible.

ALPHA'S ALTERNATIVE COURSES OF ACTION

A-1 First Strike Against Bravo
A-2 First Strike Against Charlie
A-3 No First Strike, Retaliatory Strike If Attacked

BRAVO'S ALTERNATIVE COURSES OF ACTION

B-1 First Strike Against Alpha
B-2 First Strike Against Charlie
B-3 No First Strike, Retaliatory Strike If Attacked

CHARLIE'S ALTERNATIVE COURSES OF ACTION

C-1 First Strike Against Alpha
C-2 First Strike Against Bravo
C-3 No First Strike

The analysis of the interaction will be approached by assuming an initial action has taken place and examining the resulting payoff matrix to determine if the assumed action should have been employed or avoided. Three types of interactions are possible.

1. Type I

It may be assumed that Charlie launches a first strike against either Alpha or Bravo. This action immediately invites retaliatory response from the nation attacked resulting in destruction of Charlie in the same manner as depicted in Table V for Bravo. Thus, Charlie is deterred from launching a first strike by the assured destruction capability of nations Alpha and Bravo.

It should be noted that, if for any reason the retaliatory capability of the attacked nation is not employed against Charlie, the remaining nuclear power is presented with a first strike imperative against Charlie. Such an imperative would result from the belief that the nation suffering Charlie's first strike did not in fact possess a retaliatory capability. Consequently, the interaction for the first strike imperative would be similar to that presented in Table II.

Under either set of circumstances, Charlie would not rationally be willing to launch a first strike against Alpha or Bravo. By launching a first strike Charlie ensures its own destruction if the opposing nations are constrained to act rationally.

2. Type II

A second set of interactions occurs if one of the assured destruction capable nations attacks the other. In this scenario such an interaction would be either Alpha striking Bravo or Bravo striking Alpha. This situation is identical to the situation payoffs displayed in Tables VI and VII. By launching against an assured destruction nuclear power the launching nation ensures its own destruction by inviting retaliatory response. In effect a first strike by either assured destruction capable nation obliterates both and leaves the remaining nation intact.

Consequently, if the assured destruction nations act in a rational manner they would opt for a no strike strategy. Both Alpha and Bravo would be deterred from a first strike against the other by the retaliatory capability that each possesses.

3. Type III

Finally, if it is assumed that one of the assured destruction capable nations launches a first strike against Charlie, another aspect of the interaction may be investigated. For example, a first strike by Alpha against Charlie results in the destruction of Charlie and the elimination of Alpha's first strike and assured destruction (retaliatory) capability. However, Alpha and Bravo would continue in conflict over the original issue. The payoff matrix for nation Bravo in such a situation is presented in Table X.

PAYOFF MATRIX FOR NATION BRAVO

		Nation Alpha Alternatives (No Effective Nuclear Capability)
NATION BRAVO ALTERNATIVES	B-1	Survival
	B-2	Survival/Continued Conflict
	B-3	Survival/Continued Conflict

TABLE X

Examination of Table X reveals that Bravo is presented with a dominate strategy. A first strike against Alpha ensures survival without continued conflict. Consequently, Bravo is presented with a first strike imperative against Alpha. Considering that the issue in conflict is vital to national survival, Bravo would be acting rationally if and only if it employed its first strike against Alpha.

If Alpha is a rational nation, it would not attack Charlie for to do so would present Bravo with a first strike imperative. Similarly, Bravo would not be willing to attack Charlie and present Alpha with a first strike imperative. Both assured destruction capable nations would be deterred from an attack on Charlie by the first strike imperative that such an attack would give to the other assured destruction power.

The model addressed in the presentation of the three types of interaction is a deterrence model. No participant involved in the interaction would rationally be willing to

initiate a first strike against any other participant. To do so is to invite either a retaliatory response, or present an opponent with a first strike imperative. In each of the three type interactions which compose the three nation mixed capability model, each nation would rationally follow a no strike alternative. With a no strike alternative the only rational alternative which can be implemented, the interaction results in stable mutual deterrence.

VI. SUMMARY AND CONCLUSIONS

A. THE NUCLEAR SITUATION

The advent of nuclear weaponry added a new dimension to the concept of deterrence. The dramatic increase in destructive power available to potential belligerents dictated the development of some form of nuclear restraint. Nuclear deterrence policies were envisioned as providing the required restraint. Such policies had as their ultimate goal the prevention of nuclear warfare.

As the level of nuclear capability possessed by potential belligerents increased and additional nuclear nations emerged, existing deterrence doctrines required modification. Deterrence doctrines addressed the concept of assured destruction through retaliatory response, but did not explicitly address the increase in possible interactions due to the expansion of the nuclear community. Policies of flexible response were instituted to deal with interactions other than total nuclear war.

B. THE ANALYTICAL MODEL

The method of investigating the various interactions possible in the expanded nuclear community was based on the perceived cost/benefit relationships alternative actions provided. Utilizing the basic cost/benefit relationships each alternative provided, it was possible to formulate a hierarchy of resultant values. The three resultant values specifically dealt with

were survival, survival with continued conflict, and total destruction. The resultant values were shown to be dependent in several cases upon the alternative course of action implemented by one or more opponents.

In order to display the interaction process which culminates in the resultant values a matrix format was used. By applying such a format, it became possible to analyze multination interactions as well as interactions in which participants possessed different levels of capability. The matrix display allowed for the concise presentation of complex interactions by breaking the interactions into several standard types.

C. CONCLUSIONS

From the analysis of the interactions presented in the body of the thesis, four important conclusions may be drawn. First, assured destruction provides deterrence in all cases. Regardless of the number of nations interacting, the nation which possesses an assured destruction capability deters potential aggressors by threatening their survival with its retaliatory response.

Second, nations which have only a first strike capability may present an opponent with a first strike imperative. Consequently, the failure to maintain an assured destruction capability either through loss of credibility or reduced capability might endanger a nation's survival.

Third, specific targeting doctrines are useful inasmuch as they are effective in deterring nuclear exchange at levels

below those which endanger national survival. However, such policies and targeting doctrines can not be allowed to detract from a nation's assured destruction capability without thwarting the very reason for the development of deterrence policy.

Finally, deterrence may exist in the absence of an assured destruction capability as an interaction phenomenon when three or more nations are involved. Deterrence of this type is as effective as deterrence from an assured destruction capability but it is an interaction result rather than a planned outcome by any particular nation.

D. AREAS FOR ADDITIONAL RESEARCH

The cost/benefit approach presented in this thesis opens new and interesting areas for further research. Utilizing the basic modeling procedures, maximum and minimum desirable levels of nuclear capability can be investigated. Expanding the modeling approach will allow for the investigation of nuclear interactions at levels below that of national survival. Targeting doctrines may also be investigated and analyzed for their contribution to nuclear deterrence policies.

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